EXPANSION OF THE RAW MATERIAL BASE

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USE OF LOCAL SANDS IN SHEET GLASS PRODUCTION

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Study of domestic sands from the Aleksandrovskoe deposit (Saratov Region) revealed the possibility of using these sands in sheet glass production. The use of this sand as the main silicon-containing material in the pilot production of heat-absorbing glass of a wide color spectrum is discussed.

The territory of the Saratov Region possesses substantial resources of various raw materials. The study of raw material resources and the choice of the most efficient ways for their use represent a pressing problem.

The Saratov Institute of Glass Joint Stock Company has accumulated vast experience in the study of the applicability of natural raw materials, recycled products of different industries, and alternative alkali-containing materials in the glass industry.

The present paper describes the results of investigation of a large quartz sand deposit, i.e., the Aleksandrovskii quarry whose prospective resources exceed 6 million m^3.

Silica is the most important component of industrial glasses. Of all natural raw materials containing silica, quartz sand is most often used in glass production. Its content in the glass batch exceeds 60% [1, 2]. Therefore, replacing the costly imported material with local quartz sands not only expands the available material resources, but makes it possible to substantially lower the production cost [3 – 5].

The Aleksandrovskii deposit is located 5 km from Saratov, near a railway line, and is reached by an automobile road.

The quarry consists of four benches. The sand taken from benches Nos. 1, 3, and 4 is classified as sand for construction (GOST 8736–93) due to the high content of impurities, including clay, and is used for brick production and other local needs.

The sand from bench No. 2 is of practical interest for glass production. Its capacity is 2 million m^3. The integrated investigation of the new quartz material included the following studies:

determination of chemical, mineralogical, and granulometric composition;

investigation of glass-melting properties and time/temperature conditions for glass synthesis based on the Aleksandrovskii sand.

study of physicochemical and service properties of the experimental glass.

All studies were comparative, since the analysis was simultaneously performed for the Aleksandrovskii sand and the Tashlinskii (the Ul'yanovsk Region) sand which was traditionally used in glass melting at the Saratov Institute of Glass.

The Tashlinskii sand is white with a grayish shade and consists of light and the heavy fractions; the main component of the light fraction is quartz. Its content reaches 99.8%, the feldspar content is up to 0.2% (here and elsewhere weight content is indicated). The content of the heavy fractions does not exceed 0.1% (Fe_2O_3).

The mineralogical composition of the Aleksandrovskii sand is diverse (%): 87.0 – 98.6 quartz, 5.0 – 7.0 potassium-sodium feldspar $AlSi_3O_8$; 0.15 single grains of chlorite; 2.0 calcite; not more then 2.0 muscovite; 3.0 – 4.0 argillaceous impurities; 0.35 – 1.0 heavy fractions (Fe_2O_3) [1, 2.76]. The impurities impart a yellowish shade to the Aleksandrovskii sand.

It is known that the bulk density and the granular composition of raw materials have a substantial effect on such parameters of a glass batch as looseness, caking, and mixing capacity. Therefore, an optimum granulometric composition is prescribed for each type of material, which prevents it from caking and allows for easy mixing with other batch components without stratification. The granulometric composition of the sands was investigated using the standard screening method with subsequent determination of the content of specific grain sizes [1, 2, 7.8]. It was established that the content of 0.1 – 0.6 mm fractions in the Tashlinskii sand is 97%, and in the Aleksandrovskii sand it is 93%.

The comparative granulometric analysis of the sands is given in Table 1, and their chemical composition in Table 2. The bulk density of the Tashlinskii sand is 1500 kg/m^3, and that of Aleksandrovskii is 1410 kg/m^3.

The chemical composition of the Aleksandrovskii sand is distinguished by a sufficiently high content of the main com-

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ponent (up to 96.6%), an increased content of Al_2O_3 (up to 2%), and the presence of alkali oxides (predominantly K_2O) up to 1%. The main drawback of this sand consists in its high and unstable content of iron oxide (0.3 – 1%).

The silicate and glass formation processes in experimental batches were investigated by the electron microscopic and derivatographic analysis, as well as the Zak method and the polythermal method [3, 9].

The melting properties of glass depend on the batch and glass compositions, as well as on the chemical activity of the batch components.

The factors determining the dissolution rate of the glass-forming sands include shape, clarity, and size of quartz grains and the related surface (cracks, mechanical defects} [6]. Thus, angular grains with extraneous inclusions (iron oxides, carbonates, etc.) dissolve faster than rounded pure grains [1].

A comparative electron microscopic analysis revealed that 15 and 20% of grains in the Tashlinskii and Aleksandrovskii sand, respectively, have the angular configuration, 70 and 63% have the rugged shape, and 15 and 12% have the rounded shape.

The derivatograms were taken on an OD-103 derivatograph according to the polythermal procedure within the temperature interval of 20 – 1000°C. The heating rate of the samples was 10°C/min. The DTA curves obtained in heating of batches based on the Tashlinskii and Aleksandrovskii sands had identical shapes, and there was no shift in the maxima of the respective effects toward a higher or lower temperature region.

The time it takes for the last quartz grains to disappear in the course of batch melting determines the complete melting time of glass mixtures, or the vitrification rate.

It was found that the vitrification process in both batches proceeded synchronously: the complete melting time for the Tashlinskii sand batch was 85 min and for the Aleksandrovskii sand batch it was 90 min. Hence the reactivity of both sands is similar.

The effect of the Aleksandrovskii sand on the working properties of glass was tested using mass crystallization and polythermal methods [9]. The replacement of the silicon-containing material did not affect the crystallization ability of the glass melt. The upper temperature limit of crystallization of the tested glasses was within the range of 985 – 990°C.

Based on the polythermal analysis of the batch and a series of experimental meltings in laboratory electric furnaces and in an industrial batch furnace, it was established that the melting of glasses based both on the Tashlinskii and Aleksandrovskii sands proceeds in similar temperature-time conditions. The maximum melting temperature is 1550 ± 5°C.

The samples of melted and annealed experimental glasses were analyzed for their spectral characteristics, density, and chemical stability [7]. The integrated investigation results pointed to the expediency of using the sand from the Aleksandrovskii deposit (bench No. 2) as a basic silicon-containing material for glass production.

The main industrial product of the Saratov Institute of Glass JSC is bulk-tinted sheet glass of a wide color spectrum. Therefore, the instability and increased content of such significant components as Fe_2O_3 and Al_2O_3 in the Aleksandrovskii sand composition called for correction of the basic composition of glass, analysis of permissible limits of the pigment content, and revision of the entire production technology for heat-absorbing glass.

The theoretical calculations and the analysis of laboratory and industrial test results made it possible to develop a program for gradual conversion of the experimental production line to the new quartz material. The program included several technological aspects allowing for flexible control of the color and light characteristics of heat-absorbing glass:

development of a technological scheme for sand preparation;

correction of the batch preparation cyclogram;

variations in the thermal and redox conditions of the furnace atmosphere in the batch-melting area;

development of procedures for the correction of colors, permissible limits of pigment concentration, and methods for introduction of the pigments to the batch.

The implementation of the above listed activities made it possible without stopping production to convert the line to the use of the new quartz material in a limited time. Owing to the developed technological scheme of sand preparation and the correction of the batch preparation cyclogram, 85% of the batch based on the new quartz material was quality graded as category 1 or 2. The thermal conditions selected for the burners of the glass-making furnace made it possible to maintain the zonal boundaries of the batch zone, raffinate foam zone, and pure melt zone in the same bounds as for the Tashlinskii sand. The melting of glass proceeded actively.

TABLE 1

Deposit	Content (%) of fractions (mm) in sand			
	> 0.63	0.63 – 0.315	0.25 – 0.1	< 0.1
Tashlinskii	2	47	50	1
Aleksandrovskii	4	38	55	3

TABLE 2

Deposit	Mass content in sand, %						
	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O
Tashlinskii	96.80 – 99.77	0.03 – 0.15	0.09 – 0.17	0.02 – 0.10	Traces	–	–
Aleksandrovskii	97.00 – 98.60	0.30 – 1.00	1.35 – 2.00	0.23 – 0.34	0.14 – 0.38	0.80 – 1.00	0.38 – 0.40

The main difficulty encountered in the use of the sand with high iron content consisted in the reproduction of preassigned color and spectral parameters in heat-absorbing glass.

It is known that the highest capacity for infrared absorption is exhibited by glass which contains iron in the form of Fe^{2+}. The heat-absorbing glass based on the traditional quartz material is produced according to the "oxidizing" technology [10], i.e., iron in the form of metallic powder is introduced into glass and, due to the glass melt oxygen potential and the furnace atmosphers it is oxidized to Fe^{2+} and Fe^{3+}, whereas the amount of Fe^{2+} constitutes up to 25 – 30% of the total content of iron. An increased content of iron in the form of Fe_2O_3 in the Aleksandrovskii sand makes it possible to abandon the use of metallic powder and only employ it occasionally as a minor additive, whereas the required ratio of the iron oxides (15 – 20% Fe^{2+} and 80 – 85% Fe^{3+}) is accomplished by adjusting the redox conditions in the batch-melting area.

In order to obtain bulk-colored glass, a combination of pigments is used: iron oxide (FeO, Fe_2O_3), cobalt oxide (CoO, Co_2O_3), and metallic selenium (Se). The essence of the colored glass production consists in deliberate regulation of the glass melt redox potential and selection of the quantities and ratio of the pigment components and the method of their introduction to the batch, in order to develop the required coloring centers in melting, i.e., the centers of absorption in the infrared and visible spectrum range, depending on the preassigned glass parameters.

The developed techniques made it possible to obtain glass of various color shades (from light gray to dark bronze) using the ferrous sands, and to produce glasses of M1 grade with good heat-absorbing and light characteristics (TU 21-005524989–163–96), with a glass melt utilization factor of 0.75.

Beginning with year 1994, the experimental production line at the Saratov Institute of Glass JSC was completely converted to the production of sheet heat-absorbing glass of a wide color range using the sand from the Aleksandrovskii deposit as the basic quartz material (without additional concentration).

Table 3 shows the light characteristics of the glass produced.

TABLE 3

Light transmission of glass 5 mm thick	Glass			
	light gray	gray	bronze	dark bronze
In the visible spectrum range (0.4 – 0.75 μm), %	76	72	68	43
In the IR spectrum range (0.75 – 2.5 μm), %	47	46	50	44
Total solar energy (0.2 – 2.5 μm), %	55	52	55	50

In order to improve the grade of the sand, a search for the most efficient concentration method was carried out [1, 11]. This particular ferrous sand can be efficiently improved by washing, after which it corresponds to C-070-1 grade. After the use of the float-attrition method, the sand from the Aleksandrovskii deposit can fully satisfy OVS-025-1 (GOST 22551–77) grade.

The concentrated sands in laboratory conditions were used to obtain glass samples with high spectral parameters. Thus, the light transmission of a light gray glass in the visible spectrum range can attain 80%.

The research and use of the local sand from the Aleksandrovskii deposit not only added to the available resources, but permitted a substantial decrease in the cost of the finished product (the material freight costs decreased). The correction of the basic glass composition (based on the statistical processing of data on the chemical analysis of sands) made it possible to bring down the cost of glass due to a decrease in the cost of the batch, since the iron powder is eliminated from the composition, and the amount of basic alumino- and alkali-bearing materials decreased due to the high content of Al_2O_3 and the presence of alkali oxides (Na_2O and K_2O) in the sand.

Thus, the sand from the Aleksandrovskii deposit can be successfully used as the main quartz material in the production of sheet glass. The sand can be concentrated, in order to obtain high-quality quartz and quartz-feldspar concentrates satisfying the standards of the glass and ceramic industry.

The study and the use of local sand instead of imported material contributes to the efficient integrated use of local natural resources.

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